Center Innovation Fund: GRC CIF

Plasma-Assisted Life and Ecological Operating System (PALEOS)

Completed Technology Project (2017 - 2018)

Project Introduction

Practical implementation of long-duration, human space missions will require robust, reliable, advanced life support systems. Such systems have been the subject of research since the dawn of human spaceflight.1 Once astronauts reach the surface, food and water in addition to a sustainable, breathable atmosphere are also a necessity. In situ resource utilization on the surface can greatly reduce launch mass requirements and greatly extend surface operation duration, allowing more detailed and longer duration expeditions. This effort aims to address both in-transit and surface operations life support needs for a notional human expedition to the Moon, Mars2 and beyond. At the center of this proposed life support system is nonthermal plasma as the active element. Recent advances in plasma science has enabled the application of cold plasmas for water purification, air quality control (e.g. indoor pollution), and enhanced agriculture. Electrical energy can be used to convert any atmosphere into a plasma-activated, reactive gas for the purpose of carbon dioxide breakdown and ultimate extraction of oxygen, the generation of reactive species to treat water to all for potable water recycling, the extraction of water from permafrost3, plasma treatment of seeds for enhanced yield, and the plasma treatment for water to infuse important nitrates into solution for enhanced growth (plasma agriculture).4 In the laboratory, these functions have been demonstrated. We stand at the precipice of the advancement of plasma technology that has the transformative potential to greatly both enable and simply life support systems for human spaceflight. Investment in this proposed effort is important in that it sounds the groundwork for a viable advanced life support system that is generic in application. The transportable technology can support deep space transit as well as surface operations. It only requires electrical power - power of which is used to drive electrons to support nonthermal, high selectivity chemical reactions without the need for consumables - rather it utilizes available raw materials as its feed stock firmly grounding the approach as an in situ utilization method. The goal is to show that plasma-based subsystems can form the basis for a life support system.

Anticipated Benefits

Currently, there does not exist a life support system capable of supporting deep space human proving ground missions or human missions to Mars. Plasma-based water processing offers the potential for high-value improvements in spacecraft water recovery; including, high efficiency oxidation of wastewater organics/improved ELCSS loop closure, a low temp/low pressure alternative to the Volatile Removal Assembly, improved brine quality/water recovery, wastewater and potable water disinfection/point of use processing. The effort could be a subset of a life support architecture that is scalable and generally applicable to a wide range of human mission. In this project, we have established a life support architecture that is scalable and generally applicable to a wide range of human missions. We have provided a sound footing for the plasma based approach by computationally

Plasma-Assisted Life and Ecological Operating System

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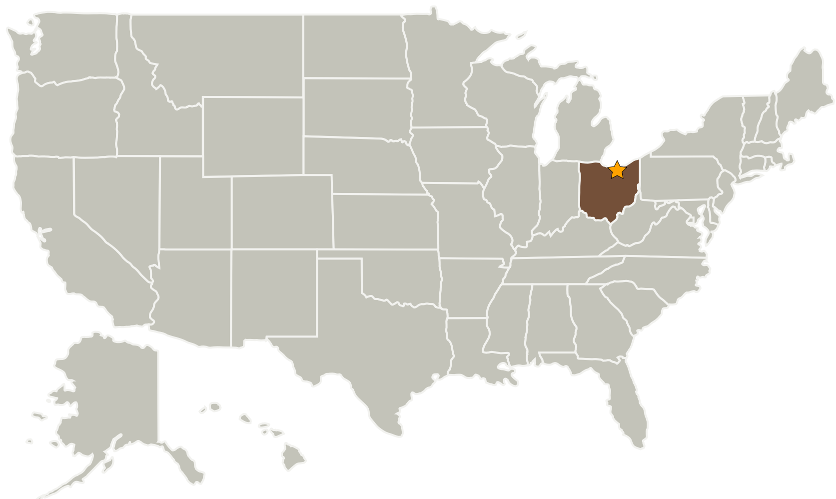
determining efficiency and power requirements for various modules supporting everything from cabin atmosphere replenishment to food production on the surface of Mars.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Glenn Research Center(GRC)	Lead Organization	NASA Center	Cleveland, Ohio
University of Michigan-Ann Arbor	Supporting Organization	Academia	Ann Arbor, Michigan

Primary U.S. Work Locations
Ohio

Project Transitions

October 2017: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Glenn Research Center (GRC)

Responsible Program:

Center Innovation Fund: GRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Managers:

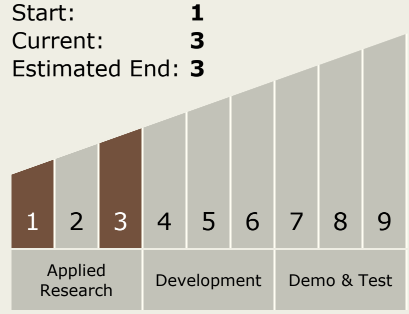
Kurt R Sacksteder
Gary A Horsham

Principal Investigator:

Isaiah M Blankson

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



September 2018: Closed out

Closeout Summary: This project has developed the engineering framework for future demonstration of plasma modules for life-support technologies. The curre nt maturity is TRL 4. This work would involve validation of well tested models to assess capability and power requirements. The effort also sets the ground work for follow-on hardware demonstrations. These demonstration experiments includ e addressing recovery of liquid and solid wastes, recovery of micronutrients, the reuse of water, and enhancement in food production. With complementary Univ ersity involvement the effort will advance laboratory apparatus into engineering models. The effort will also assist in training the next generation of scientists wit h foci on addressing Earth independent life support needs. Engineering models will be developed in a time frame such that they can be demonstrated in NASA Glenn Drop tower experiments ultimately leading to ISS flight demonstrations to further enhance design for reliability so that the technology can be applied to hu man missions to Mars and also Cis-Lunar proving ground missions.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VC

Technology Areas

Primary:

- TX07 Exploration Destination Systems
  - └ TX07.1 In-Situ Resource Utilization
    - └ TX07.1.3 Resource Processing for Production of Mission Consumables

Target Destinations

The Moon, Mars